Water-Resources Investigations Report 89-4048

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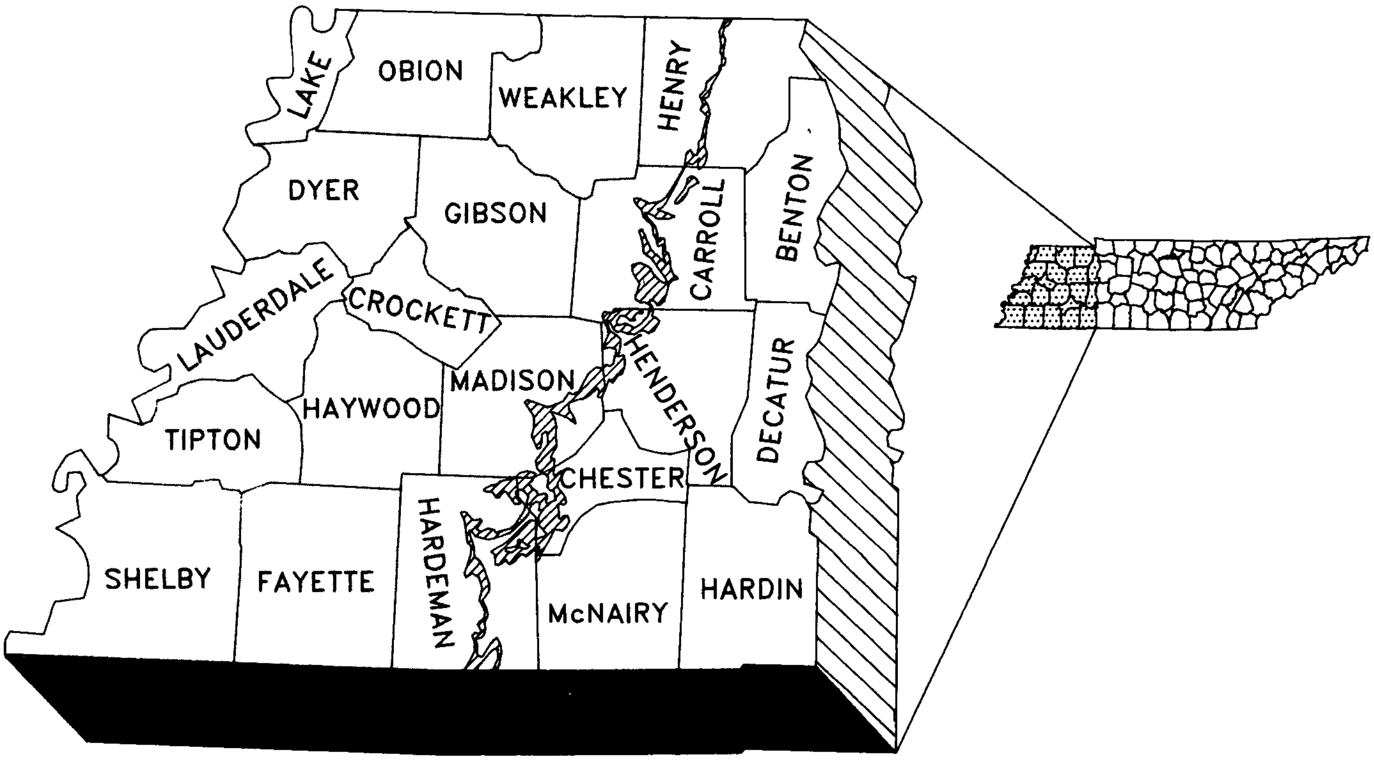

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MANUEL LUJAN, JR., Secretary

U.S. GEOLOGICAL SURVEY

Dallas L. Peck, Director

For additional information write to:

District Chief
U.S. Geological Survey
A-413 Federal Building
U. S. Courthouse
Nashville, Tennessee 37203

Copies of this report can be purchased from:

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ILLUSTRATIONS

CONVERSION FACTORS

Factors for converting inch-pound units to metric units are as follows:

Multiply	By	To obtain
foot (ft)	0.3048	meter (m)
foot per year (ft/yr)	0.3048	meter per year (m/yr)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)

Sea level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)--a geodetic datum derived from a general adjustment of the first order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

Well-Numbering System: Wells are identified according to the numbering system used by the U.S. Geological Survey throughout Tennessee. The well number consists of three parts: (1) an abbreviation of the name of the county in which the well is located; (2) a letter designating the $7^1/_2$-minute topographic quadrangle on which the well is plotted; and (3) a number generally indicating the numerical order in which the well was inventoried. The symbol Md:G-45, for example, indicates that the well is located in Madison County on the "G" quadrangle and is identified as well 45 in the numerical sequence. Quadrangles are lettered from left to right, beginning in the southwest corner of the county.

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ABSTRACT

Recharge to the Fort Pillow aquifer of Tertiary age is from precipitation on the outcrop, which forms a narrow belt across western Tennessee, and by downward infiltration of water from the overlying fluvial deposits of Tertiary(?) and Quaternary age and alluvium of Quaternary age or, where the upper confining unit is absent, from the overlying Memphis aquifer of Tertiary age. The potentiometric surface in the Fort Pillow aquifer slopes gently westward from the outcrop-recharge area, and the water moves slowly in that direction. A depression in the potentiometric surface in the Memphis area is the result of past pumping at Memphis Light, Gas and Water Division well fields (1924-74), past and present pumping at an industrial well field at Memphis, and the municipal well field at West Memphis, Ark. Withdrawals from the Fort Pillow aquifer in western Tennessee in 1985 averaged about 12 million gallons per day.

Water-level data from four observation wells, all in areas affected by pumping, indicate that water levels have declined at average rates ranging from about 0.4 to 0.9 foot per year during the past 40 years (1945-85). The greatest rate of decline was as much as 4.0 feet per year between 1945 and 1954 in an observation well in a well field of Memphis Light, Gas and Water Division at Memphis. In 1971, Memphis Light, Gas and Water Division ceased pumping from the Fort Pillow aquifer at this well field, and between 1971 and 1976, water levels rose about 28 feet in this well.

Water levels in the Fort Pillow aquifer in large areas of western Tennessee away from the effects of pumping have fluctuated only in response to long-term variations in precipitation on the outcrop-recharge belt. Long-term changes in water levels in these areas have been small.

INTRODUCTION

This report shows the altitude of the potentiometric surface in the Fort Pillow aquifer based on water levels measured in 19 wells in western Tennessee and adjacent parts of Arkansas and Missouri during September and October 1985 and describes historic water-level changes in the aquifer. The report was prepared by the U.S. Geological Survey as part of the Gulf Coast Regional Aquifer-System Analysis (GC RASA) program (Grubb, 1984). Other reports describing aquifers in Tertiary sediments in western Tennessee that were prepared as a part of the GS RASA program include reports describing the geology and ground-water resources of the Fort Pillow Sand, Memphis Sand, and the Cockfield Formation (Parks and Carmichael, 1989; 1990 a; in press a). A companion report showing the altitude of the potentiometric surface in the Memphis aquifer for the fall of 1985 and describing historic water-level changes in that aquifer also was prepared (Parks and Carmichael, in press b).

PREVIOUS INVESTIGATIONS

Maps showing the potentiometric surface of the Fort Pillow aquifer ("1,400-foot" sand) in the Memphis area in 1975 and in the Memphis urban area for the fall of 1984 were included in reports by Criner and Parks (1976) and Graham and Parks (1986). Historic water-level changes are discussed in reports by Schneider and Cushing (1948), Criner and Armstrong (1958), Criner and others (1964), Criner and Parks (1976), and Graham (1982).

AQUIFER OCCURRENCE AND CHARACTER

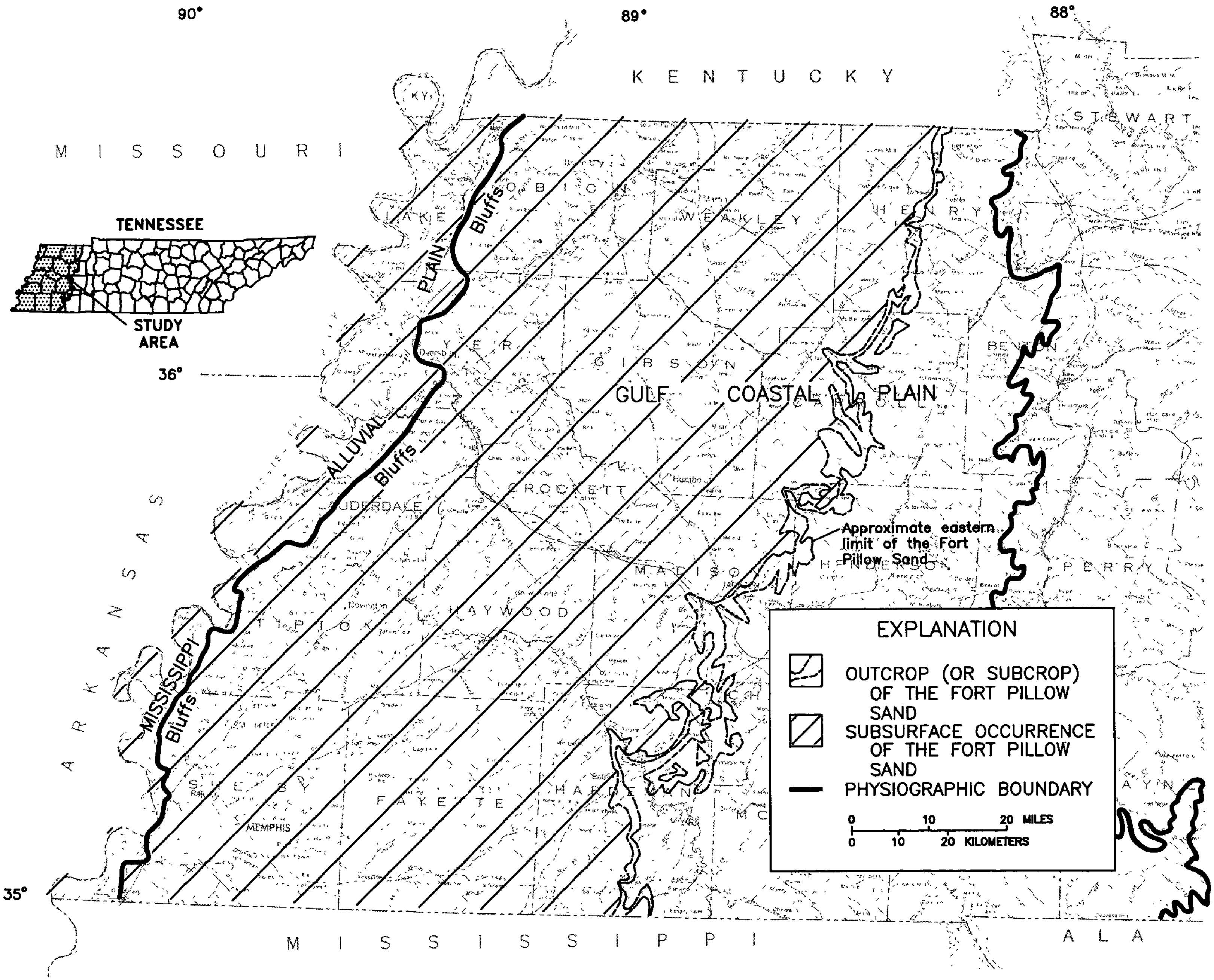
The Fort Pillow Sand of Tertiary age underlies approximately 7,700 mi^2 in the Gulf Coast Plain of western Tennessee (fig. 1). The Fort Pillow Sand consists primarily of sand that locally contains minor lenses or beds of clay or silt. The sand ranges from very fine to very coarse, but commonly it is locally fine to medium or medium to coarse.

The Fort Pillow Sand ranges from 0 to about 350 feet in thickness. The formation is thinnest along the outcrop belt in Hardeman, Madison, Carroll, and Henry Counties where it ranges from 0 to about 50 feet in thickness. The formation is thickest in northwestern Dyer County where it is about 350 feet thick. In the Memphis area, where many wells have been drilled through the Fort Pillow Sand, it ranges from 90 to 240 feet in thickness, but commonly it is about 200 feet thick. The Fort Pillow Sand would yield water to wells in most of the area of occurrence in western Tennessee and, where saturated, makes up the Fort Pillow aquifer.

The Fort Pillow aquifer provides water for public and industrial supplies in Hardeman, Madison, Carroll, and Henry Counties, just downdip from the outcrop belt, and in Shelby County in the southwestern part of the area of occurrence in western Tennessee. Withdrawals from the aquifer for public and industrial supplies in western Tennessee in 1985 averaged about 12 million gallons per day (Mgal/d). Of this pumpage, about 4 Mgal/d were withdrawn at Memphis and at Millington in Shelby County. The Fort Pillow aquifer also provides water to many domestic and farm wells in rural areas just downdip from the outcrop belt.

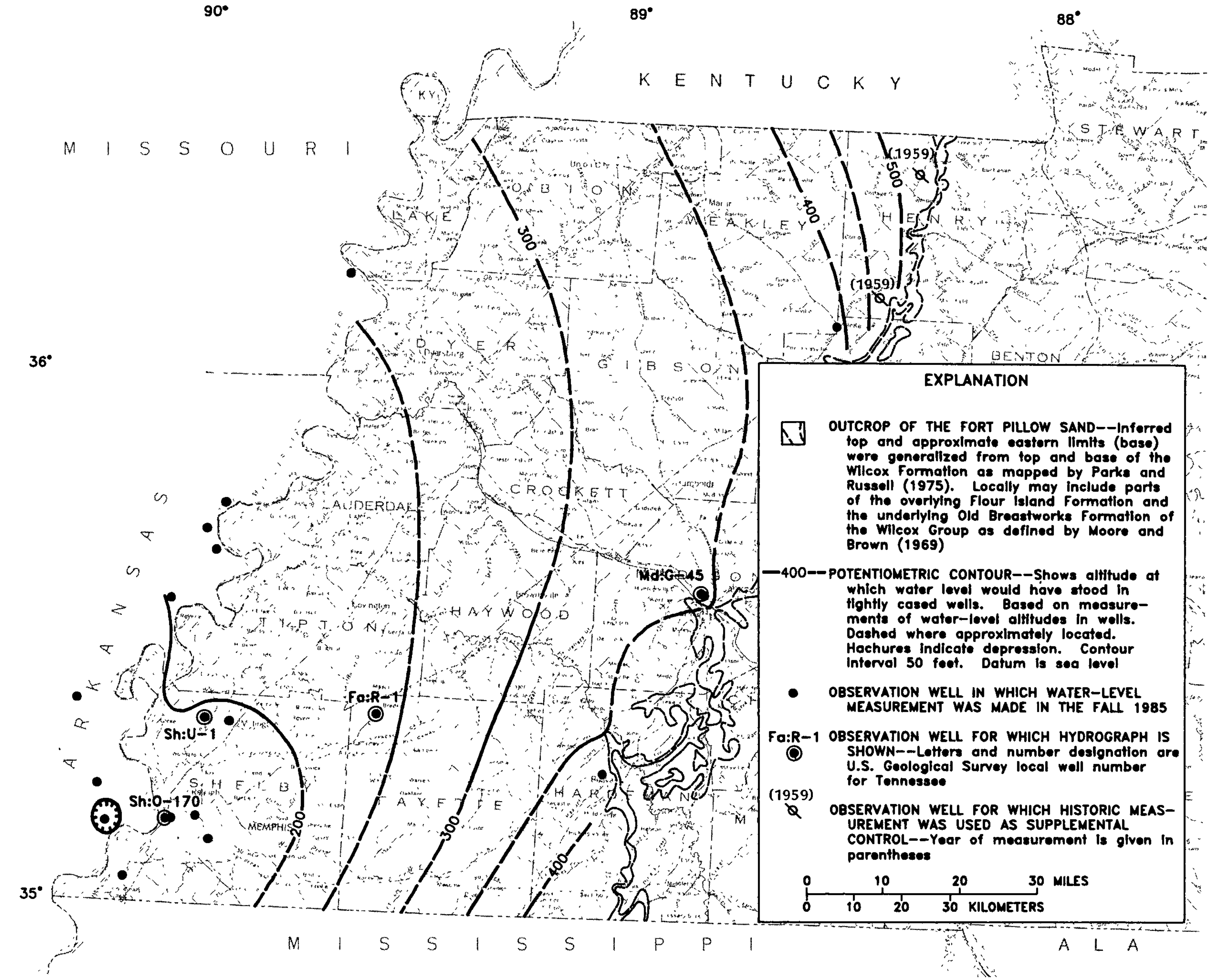
RECHARGE AND POTENTIOMETRIC SURFACE

Recharge to the Fort Pillow aquifer generally occurs along the narrow outcrop or subcrop belt where the Fort Pillow Sand is at or near the land surface (fig. 2). Recharge results from precipitation on the outcrop and downward infiltration of water from the overlying fluvial deposits of Tertiary(?) and Quaternary age and alluvium of Quaternary age. Along this outcrop-recharge belt and in the subsurface just downdip, the Flour Island Formation of Tertiary age, which is the upper confining bed for the Fort Pillow aquifer, locally is absent, and the Memphis Sand directly overlies the Fort Pillow Sand. In these areas, the Fort Pillow and Memphis aquifers have common recharge areas.



Base from U.S. Geological Survey, State base map, 1:500,000, 1973

Figure 1.--Occurrence of the Fort Pillow Sand as related to major physiographic subdivisions in western Tennessee.



Base from U.S. Geological Survey
State base map, 1973

Figure 2.--Altitude of potentiometric surface in the Fort Pillow aquifer, fall 1985.

In the outcrop-recharge belt, the Fort Pillow aquifer is under water-table conditions (unconfined). Except at seeps and springs, the water table is lower than the land surface, but generally conforms to the topography. In the outcrop-recharge belt, water moves westward down the dip of the aquifer and also toward the major streams that drain the area. Part of the water that moves toward the major streams infiltrates through the alluvium, discharges along the channels, and sustains base flows.

In the subsurface to the west of the outcrop-recharge belt where the Fort Pillow aquifer is confined by the Flour Island Formation, the potentiometric surface slopes gently westward (fig. 2), and the water in the Fort Pillow aquifer moves slowly in that direction. The depression in the potentiometric surface in the Memphis area is the result of past pumping at Memphis Light, Gas and Water Division (MLGW) well fields (1924-74), and past and present pumping at an industrial well field at Memphis, and the municipal well field at West Memphis, Ark.

HISTORIC WATER-LEVEL CHANGES

Historic water-level changes in the Fort Pillow aquifer are evident from long-term records of water levels in observation wells. Hydrographs for four observations wells in the Fort Pillow aquifer are shown in figure 3. Locations of the wells, all of which are in areas where water levels are affected by pumping, are shown in figure 2. Well Md:G-45, in Madison County, was near public and industrial well fields at Jackson (fig. 2). A water-level recorder installed on this well in late 1958 was operated until early 1973, when the well was destroyed. The water level in well Md:G-45 declined about 13.1 feet in 14 years (1958-72), an average rate of about 0.9 ft/yr (fig. 3).

Key observation wells in the Memphis area show the long-term effects of pumping on water levels in the Fort Pillow aquifer. Well Fa:R-1, in northwestern Fayette County, is the farthest of these wells from the center of the depression in the potentiometric surface in the Memphis area (fig. 2). The water level in well Fa:R-1 declined about 13.9 feet in 36 years (1949-85), an average rate of about 0.4 ft/yr (fig. 3). Well Sh:U-1, in northern Shelby County, is downgradient from well Fa:R-1 and at an intermediate distance between well Fa:R-1 and the center of the depression (fig. 2). The water level in well Sh:U-1 declined about 28.1 feet in 38 years (1947-85), an average rate of about 0.7 ft/yr (fig. 3).

Well Sh:O-170 is near the center of the depression in the Memphis area (fig. 2). This observation well is in the Mallory well field of MLGW where prior to 1972, nearby wells were pumping from the Fort Pillow aquifer. The early part of the hydrograph for this well shows extreme fluctuations of monthly low-water levels (fig. 3). The record from this well, however, is the best information available on which to base an average rate of decline of water levels in a much larger and deeper depression in the potentiometric surface that is assumed to have existed when MLGW was pumping from this aquifer. The early part of this hydrograph shows a maximum water-level decline of about 4 ft/yr between 1945 and 1954. This decline was in response to increases in pumping rates from the aquifer, beginning in 1924. In 1951, withdrawals from the aquifer in the Memphis area reached a maximum at an average rate of 15.1 Mgal/d, and then declined slightly (Criner and Armstrong, 1958, table 1). Pumping rates remained fairly constant between 1954 and 1962, but gradually declined between 1962 and 1971 (Criner and Parks, 1976, table 2). In 1971, MLGW stopped pumping from the Fort Pillow aquifer in the Mallory well field. As a consequence, between 1971 and 1976, the water level in well Sh:O-170 rose about 28 feet. The lowest water level in 1976 was about 3.5 feet higher than the lowest water level measured in

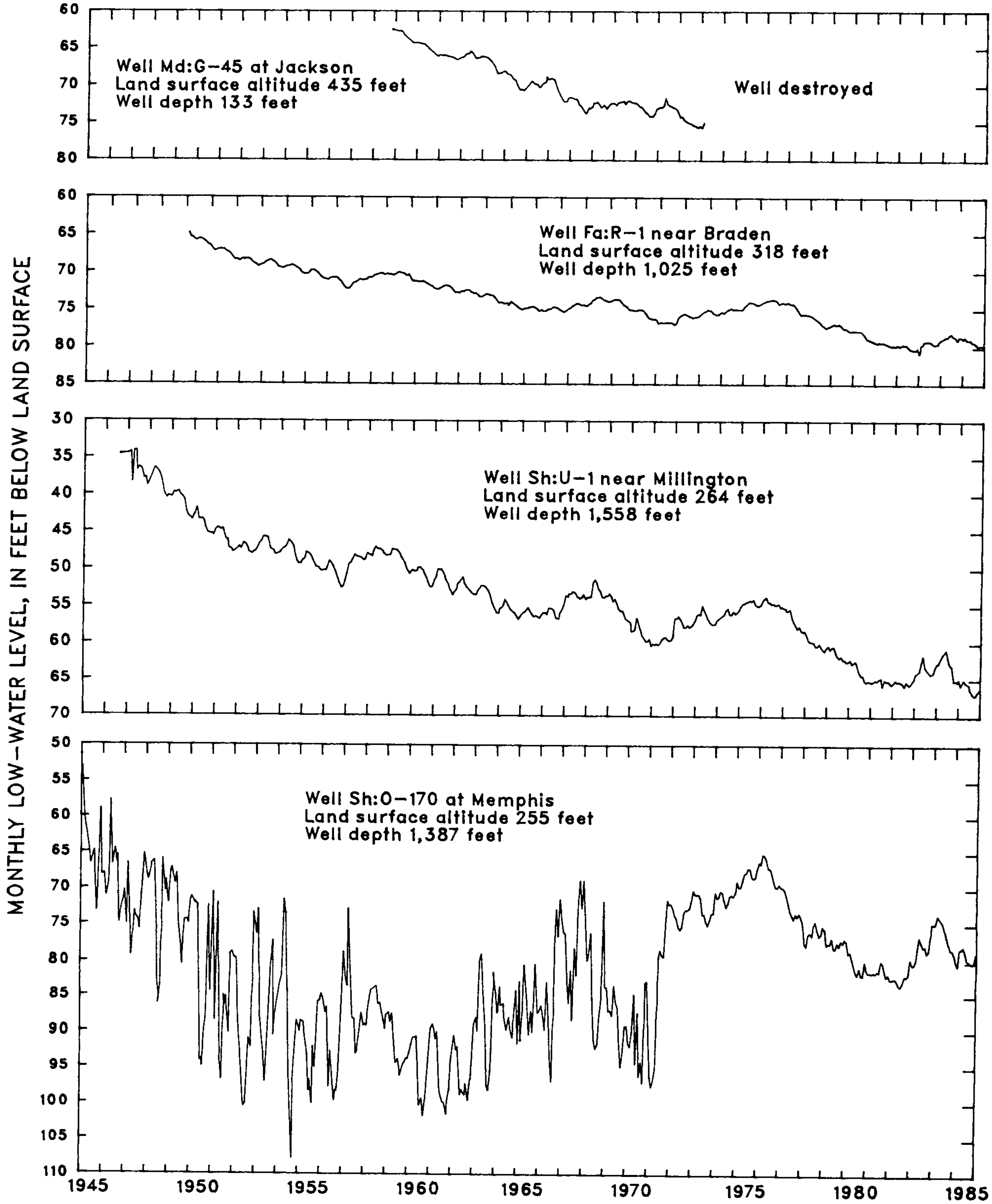


Figure 3.--Historic water level changes in the Fort Pillow aquifer.

1945. Since 1976, the water level in well Sh:O-170 has shown a declining trend as a result of continued pumping in the municipal well field at West Memphis, Ark., and in an industrial well field at Memphis.

CONCLUSIONS

Although long-term records of water levels in observation wells in the Fort Pillow aquifer for the period 1945-85 show that water levels have declined at average rates ranging from 0.4 to 0.9 ft/yr, these wells are in areas where water levels are affected by pumping at municipal and industrial well fields. Water levels in the aquifer in large areas of western Tennessee, away from the effects of pumping, have fluctuated only in response to long-term variations in precipitation on the outcrop-recharge belt. Long-term changes in water levels in these areas have been small.

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